Via ECFS

May 12, 2021

Marlene H. Dortch
Secretary
Federal Communications Commission
45 L Street, NE
Washington, DC 20554

Re: Written Ex Parte Presentation –
Addressing Threats to Public and Aviation Safety from 3700-3980 MHz Flexible Use Operations into Existing Aeronautical Radar Altimeters – Aviation and Aerospace Response to CTIA Ex Parte of March 4 2021
GN Docket No. 18-122

Dear Ms. Dortch:

The undersigned organizations ("Organizations Supporting Aviation Safety") support the Petition for Reconsideration of the Commission's March 3, 2020, Report and Order in the above-referenced docket filed by radio altimeter manufacturers, aerospace organizations, aviation organizations, and others asking the Commission to consider the potential impacts on public and aviation safety from flexible use operations in the 3.7-3.98 GHz band (referred to herein as "3.7 GHz operations"[1]) and to take appropriate mitigation measures to ensure the continued safety of flight.[2] Without taking the recommended action, the FCC will expose aviation and the traveling public to significant safety risk from interference to radar altimeters. While we understand the importance of making spectrum available to support next generation commercial wireless communications, the Petition to Ensure Aviation Safety and this letter pursue a single goal: maintaining current levels of safety of passengers and crews in the National Airspace System ("NAS") – as well as the safety of people on the ground – through

[1] This letter uses "3.7 GHz operations" to reference 5G and other commercial wireless operations that would be permitted by licensees, i.e., spectrum auctions winners and their successors or spectrum lessees, under the Commission's Rules in the 3.7-3.98 GHz band.

[2] *See* Petition for Partial Reconsideration of the 3.7-4.2 GHz Band Report and Order filed by the Aerospace Industries Association ("AIA"), the Aerospace Vehicle Systems Institute ("AVSI"), Air Line Pilots Association International ("ALPA"), Airbus, Aviation Spectrum Resources, Inc. ("ASRI"), Garmin International, Inc. ("GARMIN"), the General Aviation Manufacturers Association ("GAMA"), the Helicopter Association International ("HAI"), Honeywell International Inc. ("Honeywell"), the International Air Transport Association ("IATA"), and the National Air Transportation Association, GN Docket No. 18-122 (May 26, 2020) ("Petition to Ensure Aviation Safety"); *see also* Expanding Flexible Use of the 3.7 to 4.2 GHz Band, GN Docket No. 18-122, Report and Order and Order of Proposed Modification, 35 FCC Rcd 2343 (2020) ("Report and Order"), *petitions for reconsideration pending*.

interference-free operation of radio altimeters[3] to the exacting level of certainty demanded by aviation safety standards.

The Organizations Supporting Aviation Safety hereby respond to a March 4, 2021, ex parte letter and attachment submitted by CTIA.[4] The CTIA March 4 Ex Parte aims, but on all counts fails, to discredit the methodology and findings of the Assessment of C-Band Mobile Telecommunications Interference on Low Range Radar Altimeter Operations (the "MSG Report")[5] produced by the RTCA Multi-Stakeholder Group ("RTCA MSG") formed promptly in the wake of the Report and Order. The MSG Report finds that 3.7 GHz operations conducted under the rules adopted in the Report and Order will pose an unacceptable threat of harmful interference to today's commercial radio altimeter systems.[6] Unfortunately, the CTIA March 4 Ex Parte demonstrates a deficient level of understanding on how aviation and aerospace design, certify, manufacture, and operate equipment, as well as the fundamentals of aviation safety analysis. This faulty understanding likely would have been avoided if CTIA and its members had fully participated in the RTCA MSG as encouraged by the RTCA MSG membership throughout its work in 2020.[7] As a result, any use of the conclusions by CTIA performed without the support of rigorous technical analysis are dangerous for the Commission to consider.

Nonetheless, CTIA's nascent steps towards the issue of spectrum compatibility between 3.7 GHz operations and radio altimeters actually underscores *both* the need for the Commission to *grant* the pending Petition to Ensure Aviation Safety *and* the urgency for the Commission to work with the Federal Aviation Administration ("FAA") *to develop appropriate mitigations before 3700-3980 MHz operations commence in December 2021*, such as those which have been proposed within this docket.[8] The

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[3] Also commonly referred to as "radar altimeters".

[4] *See* Letter of Kara Graves, Assistant Vice President, Regulatory Affairs, and Doug Hyslop, Vice President, Technology and Spectrum Planning, CTIA, to Marlene H. Dortch, Secretary, FCC, and attachment thereto, "Altimeter Performance and the RTCA Study," filed in GN Docket No. 18-122 (both dated March 4, 2021) ("CTIA March 4 Ex Parte").

[5] *See* "Assessment of C-Band Mobile Telecommunications Interference on Low Range Radar Altimeter Operations," RTCA Paper No. 274-20/PMC-2073 (rel. Oct. 7, 2020), attachment to Letter of Terry McVenes, President & CEO, RTCA, Inc. ("RTCA"), to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122 (filed Oct. 8, 2020).

[6] The work of the RTCA MSG was completed with the publication of the MSG Report. For the avoidance of doubt, this letter and its attachments are not the work of RTCA or the RTCA MSG, although many of the Organizations Supporting Aviation Safety were active participants in the RTCA MSG and the preparation of the MSG Report.

[7] *See* Letter from Terry McVenes, President & CEO, RTCA, to Marlene H. Dortch, Secretary, FCC, Notice of Multi-Stakeholder Group Meeting, GN Docket No. 18-122 (filed Apr. 20, 2020). Eventual RTCA MSG participants also sought specific guidance from the Commission on the multi-stakeholder process environed by the Report and Order before beginning the work. *See* Letter of Andrew Roy, Aviation Spectrum Resources, Inc., and Clay Barber, Garmin International, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122 (Apr. 13, 2021). The efforts and results of the RTCA MSG and the subsequent but largely contemporaneous Technical Working Group-3 ("TWG-3") multi-stakeholder processes to examine the potential for 3.7 GHz operations interference to radio altimeters are summarized in **Attachment A**.

[8] *See* Letter of Karina Perez, Manager, Unmanned and Emerging Aviation Technologies, Aerospace Industries Association, *et al.*, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122 (filed Dec. 7,

Organizations Supporting Aviation Safety are committed to work with government and the commercial mobile wireless industry to achieve expeditiously a practical and achievable set of outcomes that both serves public and aviation safety and allows the American people to reap the benefits of new 3.7 GHz operations.

The inadequacy of CTIA's critique can be generally summarized as follows: One, the MSG Report submitted to the Commission is comprehensive and the result of a public and transparent process, unlike CTIA's development of *ad hoc* and isolated statements made via a high-level PowerPoint presentation in the March 4 Ex Parte. Two, CTIA, like the commercial mobile industry in general, purposely limited its involvement with aviation subject matter experts during the majority of the development of studies and never truly viewed the MSG Report through the lens of public and aviation safety. As a result, CTIA incorrectly interprets aviation standards (most significantly consideration of worst-case landing scenarios) and manifests a misunderstanding (or a gross misconstruction) of radio altimeter requirements. Three, CTIA repeatedly relies upon inappropriate comparisons with unrelated studies and services far different than the 3.7 GHz operations the Report and Order permits in the United States. Finally, CTIA's critique is plagued by unsound analysis, conjecture, and erroneous statements. These matters are discussed in more detail in the Technical Appendix, **Attachment B,** but the following are key examples of the foregoing.

- CTIA is selective in its targets and does not even attempt to challenge two of the principal findings of the MSG Report, namely (1) that 3.7 GHz operations will create serious harmful interference threats for helicopters generally, including low-altitude operations by first responders and public safety, and (2) that 5G handsets will generate deleterious spurious emissions in the 4.2-4.4 GHz frequency band (the "radio altimeter band").
- The MSG Report resulted from an open and transparent process far different than CTIA's mischaracterization. CTIA and its members were publicly invited to participate, *and even co-lead working groups*; the commercial mobile wireless industry decided not to and, instead, limited itself to submitting comments during a public comment period on the penultimate draft of the MSG Report prior to publication. These CTIA comments were included in an attachment to the final Report and considered prior to the MSG Report's publication.
- No data has been withheld from CTIA or any member of the commercial mobile wireless industry. *All data* received from AVSI in preparation of the MSG Report was publicly disclosed in the MSG Report itself. CTIA and the commercial mobile wireless industry simply have failed to take reasonable and customary steps to obtain individual, proprietary radio altimeter data from appropriate sources that other organizations have.
- CTIA exhibits its misunderstanding of fundamental aviation safety analysis by baselessly faulting the MSG Report for taking into account other sources of interference to radio altimeters using real-world scenarios, such as additional radio altimeters that have for years been uniformly installed on passenger-carrying commercial airplanes for redundancy to ensure highly-reliable safe operation; CTIA dangerously recommends that regulators ignore these additional sources of

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2021) ("Proposed Mitigations Letter"). The *Proposed Mitigations Letter* was joined by the AIA, AVSI, ALPA, ASRI, Garmin, GAMA, HAI, Honeywell, IATA, National Air Carrier Association, and Regional Airline Association.

interference and allocate the entire radio altimeter interference margin budget to deal with newly introduced 3.7 GHz operations alone.

- CTIA removes the "worst-case" from Worst-Case Landing Scenarios ("WCLS") for fixed-wing and rotary-wing aircraft, and incorrectly claims that "reasonable" and "nominal" scenarios should be the basis for determining public safety. The CTIA March 4 Ex Parte, unlike the MSG Report, provides no allowance for differences among airports, allowable variations in landing procedures, or emergency landing situations which define the proper scope of aviation safety analysis.[9]

- CTIA incorrectly compares the MSG Report with an earlier unrelated Wireless Avionics Intra-Communications ("WAIC")-radio altimeter interference analysis and mistakenly concludes that the MSG Report's methodology is inconsistent with earlier aviation safety analysis. The WAIC analysis was interim in nature, and the methods used therein have been improved to produce the data provided in the MSG Report. These improvements, in turn, are being applied to ongoing consideration of WAIC-radio altimeter compatibility. Moreover, there are fundamental differences between permitted 3.7 GHz operations and WAIC systems that CTIA fails to recognize.

- CTIA, without justification, seeks to have the Commission discount the interference effects of expected 3.7 GHz operations on widely-deployed radio altimeters that (a) are FAA-approved and FCC-certificated, (b) are in full compliance with current standards and rules, and (c) continue to be manufactured and deployed. CTIA does not actually dispute the MSG Report's finding that 3.7 GHz operations will cause harmful interference to radio altimeters operating in compliance with Part 87 of the FCC rules, but rather improperly tries to place the blame for the new risk to public and aviation safety on radio altimeters alone. CTIA's thinly veiled attempt to distract regulators obfuscates the fact that new commercial mobile wireless systems will cause harmful interference and adversely impact safety.

- CTIA's exercise of compiling a number of proposed adjustments (in dB) to the interference budget to show that there would not be interference to commercial large passenger and transport aircraft fails both because each individual element CTIA champions is without justification and because the simplistic combination of these disparate effects lacks a technical basis. The identical nature of the underlying interference mechanisms must be assessed and confirmed before adding or subtracting dB values from disparate sources, something CTIA unquestionably has not established.

- Contrary to CTIA's assertions, the commercial mobile wireless system parameters, standards, and models used in the MSG Report were provided as part of an exchange facilitated through TWG-3 or confirmed by the commercial mobile wireless industry. More importantly, the 3.7 GHz deployment scenarios evaluated reflect operational parameters permitted by the Commission's Rules. Unless and until those rules are modified to set different limits on 3.7 GHz operations, the MSG Report's use of these operational parameters is unquestionably appropriate when evaluating the potential for harmful interference.

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[9] As detailed in **Attachment C** hereto, CTIA also fundamentally misinterprets FAA obstruction rules.

- Other nations' spectrum regimes below the radio altimeter band do not support CTIA's "analysis by anecdote" but reinforce the seriousness of the potential threat presented by 3.7 GHz operations under the rules adopted in the Report and Order, as manifested by actions taken by France and by a recent letter by the Secretary General of the International Civil Aviation Organization ("ICAO") to administrations asking that they consider the serious potential for interference to radio altimeters shown by the MSG Report.
- CTIA's efforts to confuse the issues by claiming that the aviation and aerospace industry has not expressed concern about interference to radio altimeters from other existing services utilizing spectrum near the 4.2-4.4 GHz radio altimeter band ignores the reality that these services do not present a comparable interference threat to radio altimeters because they operate at much lower power levels or under different deployment scenarios than permitted by the Report and Order.

* * *

Without rigorous independent analysis, CTIA discounts the only thorough safety study supported by aviation subject matter expertise – the MSG Report – and advocates that the Commission ignore its finding that there is a clear threat to public and aviation safety risking the lives of passengers and crews. The Organizations Supporting Aviation Safety urge the Commission to grant the Petition to Ensure Aviation Safety and engage with the FAA, the aviation safety regulator, to further assess the risks to public and aviation safety demonstrated by the MSG Report and develop reasonable and appropriate mitigations. The Organizations Supporting Aviation Safety stand ready to assist the Commission and the FAA and hope that the commercial mobile wireless industry will also collaborate in good faith to ensure new 3.7 GHz operations do not undermine public and aviation safety.[10] As the Commission stated in the Report and Order, adopted when the MSG Report had not yet been conducted, radio altimeters "must operate without harmful interference."[11]

Respectfully submitted,

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Vice President, Civil Aviation

AEROSPACE VEHICLE SYSTEMS INSTITUTE

By: /s/David Redman
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[10] By supporting the Petition to Ensure Aviation Safety and asking the Commission and the FAA to take appropriate action to ensure aviation safety, the Organizations Supporting Aviation Safety do not seek to repurpose or prevent use of any part of that 3.7-3.98 GHz band. Their efforts are solely about preserving the safety of the NAS, plain and simple.

[11] Report and Order, ¶ 390.

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ATTACHMENT A

**Background on the RTCA MSG, the MSG Report,
and the Proposed Mitigations Based on the MSG Report**

In this proceeding, proponents of aviation safety and members of the commercial mobile wireless industry agreed on one thing: a multi-stakeholder group process held out the promise to address the grave issues raised by the Petition to Ensure Aviation Safety[1] concerning potential compromise to the safety functions of radio altimeters, which operate in the 4.2-4.4 GHz band, from harmful interference caused by new flexible use operations in the 3.7-3.98 GHz band.[2] The Commission's March 3, 2020, Report and Order invited interested stakeholders to voluntarily commence such a process, but did not dictate how it should be formed, what its membership should be, what issues it should address, what any deliverables should be, or under what timelines the work of any such process should be completed.[3] Nonetheless, multi-stakeholder involvement was recognized by both the aviation and aerospace industry and the commercial mobile wireless industry as a prospective means upon which the need for and content of further action to protect interference-free operation of radio altimeters could be determined.[4]

In April 2020, RTCA, Inc. ("RTCA") established the first multi-stakeholder group, the RTCA Multi-stakeholder Group ("RTCA MSG"), to reexamine these issues, and it openly invited all interested parties to join in the process.[5] While the commercial mobile wireless industry was explicitly invited and sent

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[1] *See* Petition for Partial Reconsideration of the 3.7-4.2 GHz Band Report and Order filed by the Aerospace Industries Association, the Aerospace Vehicle Systems Institute ("AVSI"), Air Line Pilots Association International, Airbus, Aviation Spectrum Resources, Inc., Garmin International, Inc., the General Aviation Manufacturers Association, the Helicopter Association International, Honeywell International Inc., the International Air Transport Association, and the National Air Transportation Association, GN Docket No. 18-122 (May 26, 2020) ("Petition to Ensure Aviation Safety").

[2] This Attachment hereinafter uses "3.7 GHz operations" to reference 5G and other commercial wireless operations that would be permitted by licensees, i.e., spectrum auctions winners and their successors or spectrum lessees, under the Commission's Rules in the 3.7-3.98 GHz band.

[3] *See Expanding Flexible Use of the 3.7 to 4.2 GHz Band*, GN Docket No. 18-122, Report and Order and Order of Proposed Modification, 35 FCC Rcd 2343, ¶¶ 333-334, 395 (2020) ("Report and Order"), *petitions for reconsideration pending*.

[4] *See* Petition to Ensure Aviation Safety at 22-24; *See, e.g.,* CTIA, Opposition to Petitions for Reconsideration, GN Docket No. 18-122, at 6 (June 26, 2020)(endorsing "the Commission's explicit interest in multi-stakeholder consideration of the coexistence issues raised in the petitions" as a potential means to address the concerns about potential harmful interference to radio altimeters); Opposition of T-Mobile U.S.A, Inc., GN Docket No. 18-122, at 7 (June 26, 2020)(touting the Commission's suggestion "that AVSI and other aviation interests can establish a multi-stakeholder group to address any matters relating to harmful interference [to radio altimeters] from terrestrial wireless use"); Opposition of AT&T, GN Docket No. 18-122, at 4 (June 26, 2020)(espousing multi-stakeholder efforts to address the complex coexistence issues concerning the introduction of flexible use in the 3700-3980 MHz and to work towards efficient technical solutions).

[5] *See* Letter from Terry McVenes, President & CEO, RTCA, to Marlene H. Dortch, Secretary, FCC, Notice of Multi-Stakeholder Group Meeting, GN Docket No. 18-122 (filed Apr. 20, 2020). RTCA members

representatives to early discussions of the RTCA MSG, it did not commit to an engagement with aviation and aerospace participants and made the decision to not collaborate on compatibility studies in that forum. CTIA and its members were invited to fully participate in the RTCA MSG and its structure, including to act as the co-lead of working groups and be involved in the remit of the work. They declined.

Subsequent to the establishment of the RTCA MSG, a second multi-stakeholder group was formed by mobile wireless, broadcasting, and internet stakeholders to tackle several technical issues in addition to the compatibility of radio altimeter and 3.7 GHz operations. While membership in this second multi-stakeholder group, like the RTCA MSG, was not exclusive or closed, unlike the RTCA MSG, it was not formed after an open public invitation nor were public updates available in the docket until late into the process. Indeed, the aviation and aerospace stakeholders only became aware of this additional MSG through one of those stakeholder's participant's early involvement in the RTCA MSG.

This subsequent multi-stakeholder group formed four technical working groups, including the so-called Technical Working Group-3 ("TWG-3") tasked with examining issues of flexible use 3.7 GHz operations compatibility with radio altimeters. While both aviation and aerospace industry and commercial mobile wireless industry representatives participated in TWG-3, this working group resulted in no studies or other output that would shed light on the matter of compatibility between 3.7 GHz operations and incumbent radio altimeters. However, TWG-3 ultimately facilitated an information exchange between the two industries, which was crucial to the RTCA MSG completing its analysis since information regarding prospective 3.7 GHz deployments was provided by the commercial mobile wireless industry. The aviation and aerospace industry, in turn, provided responses to requests for information from the commercial mobile wireless industry. The information exchange was fully documented in the MSG Report but not in any TWG-3 submission to the Commission.

Using information provided by the commercial mobile wireless industry through the TWG-3 information exchange, including some parameters that were different from the Report and Order, the RTCA MSG produced its study analyzing the potential interference for impacts on radio altimeters from prospective 3.7 GHz operations. The MSG Report was subject to a public comment process[6] prior to its publication and received an extensive list of public comments from various stakeholders, including CTIA, that were taken into account before it was completed and published. The MSG Report was filed in GN Docket No. 18-122 on October 8, 2020.[7] With the filing of the MSG Report, the work of the RTCA MSG was complete. Subsequent to its publication, the MSG Report has been widely reviewed by subject matter experts around the world and there have been no reports of "fundamental defects" that refute the findings of the Report.

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also sought specific guidance from the Commission on such a process before beginning the work. *See* Letter of Andrew Roy, Aviation Spectrum Resources, Inc., and Clay Barber, Garmin International, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122 (Apr. 13, 2021).

[6] The final MSG Report benefitted from the collaboration, inputs, and/or comments of radio altimeter design engineers, aircraft integration and operations experts, aviation safety regulators, wireless industry technical representatives, and academic researchers.

[7] *See* "Assessment of C-Band Mobile Telecommunications Interference on Low Range Radar Altimeter Operations," RTCA Paper No. 274-20/PMC-2073 (rel. Oct. 7, 2020), attachment to Letter of Terry McVenes, President & CEO, RTCA, Inc., to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122 (filed Oct. 8, 2020) ("MSG Report").

The MSG Report found through independent analysis that what aviation and aerospace industry members had cautioned the Commission about prior to the Commission's adopting the Report and Order, based on preliminary studies by AVSI completed in October 2019 and January 2020, was in fact the case: that 3.7 GHz operations under the rules adopted in the Report and Order posed a real threat of harmful interference to FAA-approved radio altimeters in widespread use today across multiple aircraft types and operations, which demanded further study.[8] The MSG Report found for the first time that, *in addition to interference from fundamental 3.7 GHz emissions, harmful interference would likely occur from spurious 3.7 GHz emissions into the radio altimeter band*. The MSG Report also made plain that mitigations must be adopted prior to 3.7 GHz operations deployments in order to manage this threat and preserve aviation safety, recognizing that it will be years until new radio altimeter standards are developed and adopted, and, then more years before equipment conforming to these standards is designed, approved, certificated, produced, and installed.[9]

The members of the aviation and aerospace industry that participated in the RTCA MSG process and TWG-3 were hopeful that the latter forum would be used, once the MSG Report was complete, to discuss appropriate mitigations using the data provided to TWG-3 as detailed in the agreed parameters to govern the group's work. Unfortunately, despite many attempts by aviation and aerospace representatives, the commercial mobile industry participants of TWG-3 were ultimately unwilling to move forward with such discussions on a consensus basis, and TWG-3 as a whole determined that further discussions would not produce a different result. Responding to the need for mitigations that could not be ignored, on December 7, 2020, eleven aviation and aerospace industry organizations and radio altimeter manufacturers, including a number of the Organizations Supporting Aviation Safety members, filed a partial set of recommended mitigations based upon the results of the MSG Report.[10] The proponents of these mitigations envisioned they will be utilized until such time as the aviation industry, employing new standards that are in the process of being developed and adopted, can produce and install new FAA-approved equipment adhering to those standards. The Organizations Supporting Aviation Safety believe these proposed mitigations, together with the findings of the MSG Report, should serve as the basis for constructive discussions by government and industry on steps that should be taken to ensure public and aviation safety before 3.7 GHz systems deploy.

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[8] *See* AVSI preliminary studies submitted into the record in Docket No. 18-122 discussed in Petition to Ensure Aviation Safety, at 9-10, nn. 24, 28, and 29.

[9] MSG Report at 88-89.

[10] *See discussion at* Letter of Karina Perez, Manager, Unmanned and Emerging Aviation Technologies, Aerospace Industries Association, *et al.*, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122, at 8-9 (filed Dec. 7, 2021). The set of proposals recognized the need for mitigations to protect helicopters (Usage Category 3 in the MSG Report) but did not include specific proposals, suggesting that any such measures required a more in-depth discussion among aviation/aerospace stakeholders, commercial mobile industry participants, the FAA, and the FCC. *Id.* at 11-12.

Attachment B

Technical Appendix: Correction of Arguments Made by CTIA in its March 4, 2021, Ex Parte Submission

The aviation industry strongly supports the Commission's efforts to realize the advantages promised by 5G through making a number of spectrum bands available to help facilitate deployment, as the industry will likely benefit from the anticipated enhanced capabilities. However, deployment of flexible use operations in the 3.7-3.98 GHz band ("3.7 GHz operations") must not degrade current levels of public and aviation safety. This is why the aviation industry has consistently sought open collaboration with all stakeholders to ensure that aircraft currently equipped with radio altimeters can continue to operate safely as new 3.7 GHz operations are deployed. The aviation industry reiterates its openness to additional, independent analyses and cooperative investigation that add to the analysis in the MSG Report.[1] Unfortunately, to date, the wireless industry has yet to engage in meaningful

[1] *See* Letter from Terry McVenes, RTCA, Inc. ("RTCA") and Dr. David Redman, Aerospace Vehicle Systems Institute ("AVSI"), to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122, at 10 (filed Nov. 19, 2020). The MSG Report itself noted the benefits and potential refinements that further analysis would likely generate:

> "Although this report is the most comprehensive assessment conducted to date regarding the potential risk of [radio frequency] interference to radar altimeters caused by 5G telecommunications signals, it is by no means exhaustive. Like any technical analysis, the work described in this report was conducted based upon certain assumptions and parameters that were refined using the best data available at the time. However, the specific implementation of 5G services, operational use cases, industry standards, or government regulations may change in the future and lead to some of these assumptions or parameters no longer being appropriate. As such, this report should not be considered as a definitive one-time assessment, but rather serve as the basis for ongoing work and analysis to continue to ensure that radar altimeters will function as intended to enable continued safe aviation operations. Further dialogue with the mobile wireless telecommunications industry to refine the analysis assumptions for such ongoing work is welcomed."

"Assessment of C-Band Mobile Telecommunications Interference on Low Range Radar Altimeter Operations," RTCA Paper No. 274-20/PMC-2073, at 8 (rel. Oct. 7, 2020) (inviting continued work and further analysis) ("MSG Report"), attachment to Letter of Terry McVenes, President & CEO, RTCA, Inc., to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122 (filed Oct. 8, 2020). For example, the MSG Report only assessed the performance of radio altimeters in the presence of a single base station. There is concern that an analysis of multiple 3.7 GHz base-stations may show even higher fundamental and spurious power levels at the input to the altimeter. However, the MSG Report does not speculate on the aggregate effect on the interference threshold exceedance based on the analysis for the single base station case.

collaboration that leverages resident subject matter expertise to produce a mutually beneficial result. The CTIA ex parte letter filed in Docket No. 18-122 on March 4, 2021, does not remedy this situation.[2]

The CTIA March 4 Ex Parte continues to confound the record and overlooks real dangers posed to public and aviation safety. It is devoid of sound and informed technical analysis. It reiterates claims from previous filings that have been shown to be inaccurate. It raises non-technical and often contradictory arguments, and draws comparisons to outdated studies that have no relevance to the analysis and findings in the MSG Report. The CTIA March 4 Ex Parte is presented as a technical analysis, yet no rigorous analytical basis is provided to support its claims. Unlike the MSG Report. which it criticizes, the CTIA March 4 Ex Parte is not the result of an open, transparent process and suffers from lack of consultation with aviation subject matter experts.

The many flaws in the CTIA "analysis" fall into three broad concerns: (1) CTIA makes false claims regarding the transparency of the process used to develop the MSG Report that are easily refuted by the record; (2) the CTIA March 4 Ex Parte repeatedly reflects a fundamental misunderstanding of aviation systems and operations in general, and radio altimeter requirements in particular; and (3) CTIA's conjectures and its comparisons to unrelated studies are unfounded and inappropriate. This attachment addresses each of these concerns below.

Because of CTIA's flawed analysis, refusal to consider aviation industry practice and expertise, and failure to substantiate its critique, the Commission should reject all claims and recommendations made in the CTIA March 4 Ex Parte and previous CTIA filings concerning the threat of harmful interference and subsequent impact to public and aviation safety.

1. CTIA Does Not Dispute the MSG Report's Finding of Interference from 5G Spurious Emissions

At no time has CTIA challenged the key finding of the MSG Report that flexible use operations in the 3.7-3.98 GHz band will generate spurious emissions into the 4.2-4.4 GHz band and pose a threat to public and aviation safety. The analysis in the MSG Report demonstrates that, based on information provided by CTIA, 3.7 GHz emissions from both Advanced Antenna System ("AAS") and fixed sectoral antenna base stations will exceed interference tolerance thresholds for radio altimeter Usage Categories ("UCs") 2 and 3 for the scenarios that were studied.[3]

However, the MSG Report goes on to show that both the fundamental and spurious 5G emissions at levels allowed under the March 3, 2020, Report and Order,[4] which are higher than those

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[2] *See* Letter of Kara Graves, Assistant Vice President, Regulatory Affairs, and Doug Hyslop, Vice President, Technology and Spectrum Planning, CTIA, to Marlene H. Dortch, Secretary, FCC, and attachment thereto, "Altimeter Performance and the RTCA Study," filed in GN Docket No. 18-122 (both dated March 4, 2021) ("CTIA March 4 Ex Parte").

[3] *See* MSG Report, Figure 10-24 at 71 and Figure 10-28 at 73. The MSG Report, at 34-35, groups radio altimeter types into three usage categories: Usage Category 1 ("UC1") covering commercial air transport airplanes, both single-aisle and wide-body; Usage Category 2 ("UC2") covering all other fixed wing aircraft not included in UC1, including regional, business aviation, and general aviation airplanes; and Usage Category 3 ("UC3") covering transport and general aviation helicopters.

[4] *See Expanding Flexible Use of the 3.7 to 4.2 GHz Band*, GN Docket No. 18-122, Report and Order and Order of Proposed Modification, 35 FCC Rcd 2343, ¶¶343, 347 (2020) ("Report and Order"),

provided by CTIA, exceed radio altimeter protection criteria established in international regulatory processes across all categories of radio altimeters. These exceedances exist for handsets carried on board aircraft in all three UCs and are summarized in Table 1, with positive exceedance values indicating that the protection criteria are not met, and harmful interference may occur.

Table 1: Interference Threshold Exceedances ("ITE") for User Equipment ("UE") On Board Aircraft

Type of 3.7 GHz Emission	ITE by UC			Rec ITU-R M.2059 Criteria	MSG Report Source
	UC1	UC2	UC3		
UE Fundamental	+2.2 dB	+12.2 dB	+25.2 dB	Overload Protection	Table 10-1 (at 85)
UE Spurious	-11.8 dB	-1.8 dB	+11.2 dB	False Altitudes	Table 10-2 (at 86)
UE Spurious	+2.2 dB	+12.2 dB	+25.2 dB	Receiver Desensitization	Table 10-2 (at 86)

Note that these exceedances are independent of the empirically determined interference tolerance thresholds measured by AVSI and are based on International Telecommunications Union – Radiocommunication ("ITU-R") Recommendation M.2059, which establishes protection criteria for radio altimeters that have been in place since 2014.[5] Thus, the CTIA March 4 Ex Parte recommendation to dismiss the findings of the MSG Report based largely on faulty analysis of the AVSI measured thresholds is both disingenuous and, ultimately, immaterial since CTIA does not dispute the Report's findings that operations in 3.7-3.98 GHz permitted by the rules adopted by the Commission will indeed cause harmful interference according to relevant ITU-R-established protection criteria.

2. The MSG Report Was Produced Using a Technically Sound and Transparent Process

CTIA's claims that the MSG Report conclusions are invalid due to a lack of transparency are simply unfounded. The aviation industry has consistently sought collaboration from all stakeholders with relevant subject matter expertise as documented in the record of Docket No. 18-122 and in the MSG Report itself. The scope of the MSG Report, whose effort began without preconceived notions, was to (1) establish whether harmful interference could be caused by 3.7 GHz operations permitted by the rules adopted in the Report and Order and, if so, (2) the extent of the risk of such harmful interference. These are objectives that the MSG Report has unequivocally accomplished in a manner that is technically rigorous, inclusive, and transparent.

CTIA's efforts to critique the process as less than transparent are contrary to the facts. As described in the accompanying **Attachment A**, the RTCA MSG, following the Report and Order's encouragement of such efforts, was established through open invitation in the public record,[6] produced

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petitions for reconsideration pending (discussing 3.7 GHz operations base station and user equipment out-of-band emissions limits).

[5] Recommendation ITU-R M.2059, Operational and Technical Characteristics and Protection Criteria of Radio Altimeters Utilizing the Band 4 200-4 400 MHz (02/2014).

[6] *See* Letter from Terry McVenes, President & CEO, RTCA, to Marlene H. Dortch, Secretary, FCC, Notice of Multi-Stakeholder Group Meeting, GN Docket No. 18-122 (filed Apr. 20, 2020). Those members of the Organizations Supporting Aviation Safety that participated in the RTCA MSG were pleased when members of the commercial mobile industry attended the first few meetings, but ultimately, for reasons not made known to the other participants, the representatives from the commercial mobile industry stopped attending the RTCA MSG effort. *See also* fuller description of the RTCA MSG in **Attachment A.**

a technically sound report that uses input from the industries and agencies that have the resident subject matter expertise to provide such input, and provided for a public comment period prior to publication. All data provided to and used by the RTCA MSG are clearly documented in the MSG Report and are traceable to the Report and Order, accepted standards, regulatory guidance, and subject matter expert review. The MSG Report catalogued all public comments received and their resolution, including comments received from CTIA.[7] While not all recommendations or critiques provided by reviewers were incorporated in the body of the final MSG Report, the rationale for not including them is expressly provided.

In Technical Working Group-3 ("TWG-3"), wireless industry experts provided aviation industry experts with what they described as representative 5G technical parameters.[8] However, they refrained from providing detailed parameters for proprietary deployments being considered by CTIA members. Similarly, aviation industry experts provided representative, non-proprietary radio altimeter technical parameters based upon proprietary altimeter designs.[9] The MSG Report provides the rationale for using representative and aggregated characteristics as the appropriate means of establishing tolerance thresholds while also explaining the means by which the wireless industry can pursue individual radio altimeter characteristics, if desired.[10] There has been ample opportunity in the ensuing months for CTIA and its commercial mobile industry members to request additional information from AVSI and radio altimeter manufacturers.[11] But they have taken no such steps. Furthermore, the aviation industry participants provided radio altimeter technical parameters to the wireless industry without constraints as to their use. By contrast, the wireless industry provided 5G parameters subject to a restrictive set of constraints and disclaimers aimed at limiting independent analyses.[12]

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[7] *See* MSG Report, Appendix D at 152, 154-156, 158-159, 167-169, 173, 177-178, 183, 192-195, 198-200.

[8] *See* Letter from Max Fenkell, Co-Chair, TWG-3, and Kara Graves, Co-Chair, TWG-3, to Marlene Dortch, FCC, written *ex parte* presentation, GN Docket No. 18-122 (filed Nov. 13, 2020) ("TWG-3 Final Report").

[9] The details of these exchanges are fully disclosed in the MSG Report. *See* MSG Report, Appendix B at 116-150. Notably, the scope of the exchange was substantially more extensive than described in the TWG-3 Final Report.

[10] MSG Report at 134. The written response from the aviation industry experts to the wireless industry experts stated, "The wireless stakeholders expressed an interest in obtaining the exact performance characteristics, including receiver [frequency-dependent rejection] and overload thresholds, for several different altimeter models. This data would be considered proprietary by the individual altimeter manufacturers, and there is no mechanism to obtain or distribute it through AVSI or RTCA. Therefore, the wireless stakeholders would need to work with the individual altimeter manufacturers to set up [non-disclosure agreements] and determine what data could be shared. However, if this approach is taken, all FAA-approved altimeter models must be considered in order for the analysis to sufficiently characterize the current deployment of radar altimeters in the civil and commercial aviation markets. This is understandably a difficult task to achieve, which is why the aviation stakeholders . . . have instead taken the approach of using representative datasets."

[11] Other organizations have followed the steps outlined to the commercial mobile industry, and AVSI, in response, is working with these organization to provide AVSI proprietary information, under appropriate protections, to support additional technical analysis.

[12] *See* MSG Report at 140.

3. CTIA Misconstrues Relevant Aviation Safety Standards, Radio Altimeter Requirements, and Applicable Regulation

The CTIA March 4 Ex Parte displays a lack of understanding concerning aviation and aerospace design, certification, manufacturing, and operations, including the fundamentals of aviation safety analysis. The absence of this foundation invalidates the premises underlying many of CTIA's arguments and results in flawed critique of the Worst-Case Landing Scenario ("WCLS") analyzed in the MSG Report, incorrect interpretation of aviation standards, misconstruction of radio altimeter systems requirements, and an inaccurate portrayal of Commission regulation for avionics and how that relates to the FAA's certification process.

a. Incorrect consideration of the Worst-Case Landing Scenario

A primary example of CTIA's lack of understanding of aviation subject matter is its mischaracterization of the WCLS used in the MSG Report.[13] In seeking to redefine the WCLS, the CTIA March 4 Ex Parte misapplies FAA Order 8260.3E, which defines Terminal Instrument Procedures at aerodromes. O8260.3E clearly describes the limits of its limited applicability:

> This order prescribes standardized methods for designing and evaluating instrument flight procedures (IFPs) in the United States and its territories. It is to be used by all personnel responsible for the preparation, approval, and promulgation of IFPs. *These criteria are predicated on normal aircraft operations and performance.*[14]

In other words, O8260.3E did not seek to describe all scenarios possible, including the worst case, and thus CTIA's reliance on it to critique the MSG Report's WCLS analysis is misplaced. The WCLS is, by definition, *not* intended to reflect "normal aircraft operations," but rather a *plausible* operational scenario that presents a worst-case condition in which radio altimeters are still required to meet their minimum performance criteria. The WCLS used by the MSG Report has been reviewed and validated by aviation experts including FAA and other international aviation safety regulators, aircraft operators, air traffic controllers, aircraft manufacturers, aircraft equipment manufacturers, and international aviation spectrum experts and conforms to the worst case used in other studies (such as the WAIC preliminary report discussed below).[15]

The CTIA March 4 Ex Parte observes that O8260.3E defines a maximum Threshold Crossing Height ("TCH") of 60 feet[16] but then goes on to misuse Table 10-1-1 from O8260.3E to erroneously claim that the WCLS used in the MSG Report "artificially exaggerates" interference conditions. Apart from the

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[13] *See id.* at 106-109 (describing the WCLS).

[14] FAA Order 8260.3E, United States Standard for Terminal Instrument Procedures (TERPS) (Sep 17, 2020) at 1-1 ("O8260.3E") (emphasis added).

[15] *See* MSG Report, Appendix C at 187. The WCLS described in the MSG Report was reviewed by aviation and wireless industry members and generated several comments captured in the peer review table in Appendix C of the Report. Additionally, similar geometries have been used in other unrelated studies at the International Civil Aviation Organization ("ICAO"). *See* Radio Altimeter Interference Susceptibility Testing Status Update, Seventh Working Group Meeting of the Frequency Spectrum Management Panel (FSMP – WG/7), Johannesburg, South Africa, 6-13 September 2018; *see also* ITU-R, Report ITU-R M.2319, Compatibility analysis between wireless avionic intra-communication systems and systems in the existing services in the frequency band 4 200-4 400 MHz (11/2014). The 200 feet height above ground used in ITU-R M.2319 is also used in the MSG Report.

[16] *See* O8260.3E at 10-4.

fact that the MSG Report never claims, as CTIA alleges, that the 200-foot altitude in the WCLS corresponds to a TCH, CTIA grossly misinterprets and oversimplifies the 526-page O8260.3E, ignoring many factors considered necessary by aviation experts in understanding WCLS. For example, O8260.3E states that the TCH refers to the *design TCH* for aerodromes, thus providing guidance for proper implementation of ground-based landing assistance systems. Actual aircraft operations, by contrast, include situations like missed approaches in which a height above ground level of 200 feet in the WCLS geometry can occur. By definition, every approach clearance includes a clearance for the missed approach,[17] and therefore the missed approach scenario must also be protected in every manner. Considering the landing decision height minimum for an instrument landing system ("ILS") Category I approach is typically 200 feet, and allowing for descent below the decision height during the transition to the missed approach, flying over the approach end of the runway at 200 feet should be expected. Additionally, CTIA does not account for other factors in the FAA's procedure design process, such as terrain or obstacles that allow for a higher TCH when required by airport constraints.[18]

The CTIA March 4 Ex Parte further misinterprets the geometry of the WCLS illustrated in the MSG Report to imply that aircraft can never simultaneously experience *both* harmful interference from 3.7 GHz band wireless sources *and* interference from nearby radio altimeters while approaching an airport for landing. However, the WCLS geometry used in the MSG Report captures the plausible real-world scenario under existing aviation regulations that provides an appropriate case for analysis. The WCLS is not intended to represent any specific airport or unique configuration, and there are other airport configurations that lead to similar interference conditions, which the MSG Report explicitly recognizes.[19] Airports may have runway configurations in which the threshold of a specific runway may be offset from the end of an adjacent taxiway, as illustrated below for runways 28C and 28R at O'Hare International Airport (KORD). Such a geometry appropriately allows for a landing aircraft to be exposed to interference from the radio altimeters onboard aircraft on the ground as modeled by the WCLS, prior to even reaching the runway threshold.

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[17] FAA, Aeronautical Information Manual (Dec. 31, 2020) paragraph 5-4-21.h at 5-4-58 ("A clearance for an instrument approach procedure includes a clearance to fly the published missed approach procedure, unless otherwise instructed by ATC") *available at* https://www.faa.gov/air_traffic/publications/media/aim_basic_w_chg_1_2_3_dtd_12-31-20.pdf.

[18] The TCH may be increased when an obstacle penetrates the vertical guidance surface. *See* O8260.3E at 2-54. A TCH increase above the 60-foot maximum is allowed via a waiver of the FAA's procedure design criteria. *See* FAA Order 8260.19I, Flight Procedures and Airspace (Jun 29, 2020) at 2-40-2-42. Additionally, O8260.3E itself envisions TCH increases above the 60-foot maximum because Table 3-1-3 shows that credit for an approach lighting system can be applied to a TCH Upper Limit of 75 feet. *See* O8260.3E at 3-5. Further, TCH values above 75 feet exist; for example, the Duluth International Airport (KDLH) ILS or LOC RWY 27 approach chart shows a TCH of 80 feet. Other United States airports with a TCH greater than 60 feet include Reno/Tahoe International Airport (KRNO), Palm Beach International Airport (KPBI), and San Diego International Airport (KSAN); many other examples exist.

[19] *See* MSG Report n. 48 at 107 ("although Figure A-2 shows the aircraft crossing the runway threshold at 200 feet AGL, this worst-case altitude need not correspond to the actual threshold crossing height. Other situations may also lead to the same WCLS geometry where radio altimeter operation is critical, for example if the ends of the taxiway and apron are not aligned with the runway threshold").

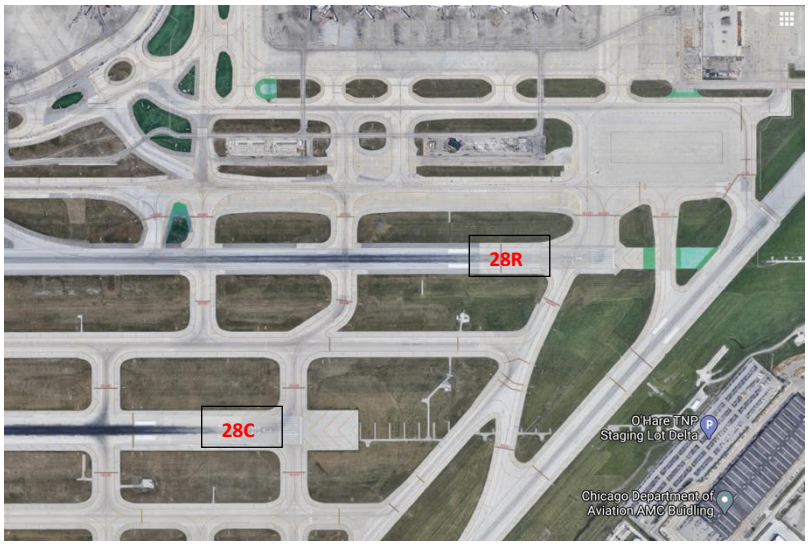

Figure 1: Aerial View of O'Hare Airport (from Google Maps[20])

The CTIA March 4 Ex Parte makes other claims regarding the WCLS that have readily been refuted. CTIA asserts that the WCLS used in the MSG Report exaggerates interference conditions since the applicable radio altimeter minimum operational performance standard ("MOPS"), DO-155,[21] does not specify that in-band frequency-modulated continuous wave ("FMCW") interference from off-board radio altimeters must be considered in compliance testing. CTIA incorrectly conflates the purpose of (1) a MOPS, which is generally used as the performance standard establishing minimum design criteria for avionics equipment to allow use of such equipment onboard FAA-certified aircraft through the Technical Standard Order ("TSO") process, with (2) the MSG Report's purpose of establishing radio altimeter susceptibility. While MOPS testing ensures that radio altimeters will operate as required in prescribed conditions, the testing described in the MSG Report was designed to ascertain whether and at what point radio altimeters are unable to meet aviation requirements in a real-world environment where 3.7 GHz operations are introduced. Furthermore, CTIA fails to understand that DO-155 is not the primary specification used for FAA certification. FAA TSO-C87a is the current regulatory basis for certification of radio altimeter equipment, and it refers to EUROCAE ED-30 as the primary performance standard.[22]

While EUROCAE ED-30 and DO-155 do not explicitly include radio frequency ("RF") interference test sources in the standard test setup description, neither do they support CTIA's contention that such

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[20] Google Maps, retrieved April 25, 2021 (runway identifiers added) *available at* https://www.google.com/maps/place/41%C2%B057'56.7%22N+87%C2%B053'34.6%22W.

[21] *See* RTCA, Inc., DO-155, Minimum Performance Standards Airborne Low-Range Radar Altimeters (Nov. 1, 1974) ("DO-155"). The CTIA March 4 Ex Parte, Att. at 6 states RTCA DO-155 is "aviation's standard for altimeter performance"; however, as explained *infra*, this is not the case.

[22] *See* FAA, TSO-C87a, Airborne Low-Range Radio Altimeter (May 31, 2012) ("TSO-C87a") at 1 (stating that the applicable minimum performance standard is "EUROCAE document ED-30"). TSO-C87a does reference DO-155 as well, but only for the calculation of external loop loss. *See id.* at 8. *See also* EUROCAE, ED-30, Minimum Performance Specification for Airborne Low Range Radio (Radar) Altimeter Equipment (March 1980) ("ED-30"). Prior to the introduction of TSO-C87a, the minimum performance standards had been defined directly within the TSO document, TSO-C87, without reference to any external documents, such as DO-155. See FAA, TSO-C87, Airborne Low-Range Radio Altimeter (Feb. 1, 1966).

interference sources should not be considered.[23] Additionally, it would be unsound for radio altimeter manufacturers to design a system in isolation, without accounting for the in-band RF environment they will encounter from different airport layouts and landing scenarios. This is part of the proper design that manufacturers go through to develop safety systems such as radio altimeters.

In addition, CTIA's assertion that in-band interference should not have been included in the MSG Report since compatibility testing must strictly comply with the letter of the certification testing described in applicable performance specifications directly contradicts its later recommendation that risk assessment tests should ignore the ground reflectivity specified in DO-155 and use a more favorable value. CTIA's proffered critique should be discounted since it selectively and without adequate justification extracted bits of information from a variety of performance standards established for different purposes that superficially appear to support their arguments, rather than perform an independent analysis of radio altimeter and 3.7 GHz system compatibility.

The CTIA March 4 Ex Parte also claims the MSG Report's WCLS "would require placing the 5G tower in a location that violates FAA rules about obstructions to air navigation."[24] This erroneous claim is thoroughly debunked in **Attachment C,** an Analysis of FAA Obstruction Rules, which shows the FAA's regulatory framework allows an obstacle such as base station tower to be located nearby a precision approach runway threshold. More importantly, **Attachment C** also shows, via an Analysis of Existing Towers Nearby Airport Approaches, that there is a widespread and increasing risk of harmful interference to all radio altimeter Usage Categories from existing (as of June 2020) base station towers far removed from a runway threshold. Accordingly, the consideration of 3.7 GHz base stations by the MSG Report WCLS is completely justified.

Finally, it is significant that the CTIA March 4 Ex Parte's critique of the WCLS is limited solely to the case for UC1 large commercial transport aircraft. CTIA fails to consider the worst case scenarios of helicopters and general aviation aircraft. This is especially significant because the MSG Report demonstrates that the most significant exceedances of measured interference thresholds by 3.7 GHz emissions occur for UC2 and UC3 radio altimeters, which are used in business, regional, and general aviation airplanes and transport and general aviation helicopters, respectively.[25]

At most, the only aspect of CTIA's WCLS critique that might impact the findings of the MSG Report for general aviation aircraft is the removal of in-band interference representative of off-board radio altimeters at 200 feet for UC2[26] – but it is inconsequential. The MSG Report indicates a contribution of only 8 dB in the tolerance thresholds at 200 feet from the interference of 3.7 GHz operations (-76 dBm/MHz for UC2 with the WCLS in-band interference sources, compared to -68 dBm/MHz for UC3 without the WCLS in-band interference sources).[27] This demonstrates that even if the additional off-board radio altimeter in-band FMCW interference in the WCLS configuration were entirely removed, interference from 3.7 GHz operations would still exceed the established tolerance by more

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[23] This lack of specification is currently being examined in RTCA Special Committee 239 and EUROCAE Working Group 119, which were organized to update radio altimeter MOPS. These new MOPS will take account the radio frequency environment that is evolving around the 4.2-4.4 GHz band in order to ensure the protection of the flying public.

[24] CTIA March 4 Ex Parte, Att. at 35.

[25] *See* MSG Report, Executive Summary at i.

[26] For UC3, these in-band interference sources are already excluded. The UC2 and UC3 cases are otherwise identical.

[27] *See* MSG Report, Figure 9-4 at 51 for UC2 and Figure 9-7 for UC3.

than 30 dB for UC2 and UC3 radio altimeters at low altitudes.[28] Further still, the WCLS only directly affects the measured interference tolerance at an altitude of 200 feet, and significant exceedance of the thresholds from 3.7 GHz signals was also observed at higher altitudes where the WCLS does not apply.[29] Thus, the claims concerning the WCLS are erroneous, and irrelevant for helicopters and general aviation aircraft, *i.e.,* UC2 and UC3.

b. Incorrect interpretation of aviation standards

The CTIA March 4 Ex Parte makes incorrect assumptions inconsistent with cable losses that are experienced by radio altimeters in the real world and thoroughly described in the MSG Report.[30] CTIA misconstrues the guidance provided in DO-155 regarding calculating loop loss by applying it to support CTIA's incorrect statement that cable losses should not be incorporated in interference testing.[31] DO-155 states that equipment under test is to be adjusted in accordance with the manufacturer's recommended practices prior to testing, which considers the manufacturer's recommended installation cable losses. Further, the loop loss calculation methods described in DO-155 Appendix B and Appendix C, along with the example loop loss curves provided in DO-155 Appendix B, deal explicitly with *external* loop loss, which only includes the round-trip propagation losses from the transmitting antenna to the receiving antenna. By contrast*, total* loop loss, which is defined in reference to the transmit and receive ports on the radio altimeter, is the sum of the external loop loss and any cable losses in the installation between the radio altimeter and the antennas. The inclusion of external loop loss alone gives the DO-155 standard a flexibility that allows it be applied to radio altimeters having different installation characteristics (including appropriate consideration of all cable losses).[32] As a result, DO-155 *cannot* be read to imply that losses other than external loop loss can be ignored in assessing compliance with minimum operational performance requirements.

Further, CTIA misrepresents the external loop loss for a 200-foot height, claiming it is 90 dB[33] when in fact the external loop loss defined by DO-155 for a 10.8 dB antenna gain assumption is 92 dB at 200 feet.[34] CTIA's errors undermine its specific critiques related to loop loss. As a result, all CTIA claims and statements concerning cable and loop losses should be dismissed.

c. Incorrect understanding of radio altimeter system requirements

CTIA makes inaccurate claims that the radio altimeter compatibility testing should incorporate the pilot's display tolerance as outlined in DO-155.[35] The "pilot's display" accuracy requirements in DO-155, and the related ED-30 MOPS, are relaxed only to allow for additional error imparted by the indicator or display itself (since these components also must have TSO authorization under the same standards). This allowance in the standards does *not* mean that the altimeter accuracy requirement is relaxed in any way, as CTIA implies. The radio altimeter accuracy requirements are necessary to support

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28 *See id.*, Figure D-13 at 211.

29 *See id.*, Figure D-9 at 209 for UC2 and Figure D-13 for UC3.

30 *See id.* at 37.

31 *See* CTIA March 4 Ex Parte, Att. at 6 and 13.

32 DO-155, Appendix A at 1 states that "external loop loss is the ratio of the available power entering the receiving antenna aperture to the power leaving the transmitter antenna aperture" and that this external loop loss "is independent of antenna and *transmission line losses*" (emphasis added).

33 *See* CTIA March 4 Ex Parte, Att. at 6 and 13.

34 DO-155, Appendix B at 9.

35 *See* CTIA March 4 Ex Parte, Att. at 14 and 22.

the operation of other systems critical to the safe operation of the aircraft. A number of these systems, such as the terrain avoidance warning systems ("TAWS"), directly use the altitude reported by the radio altimeter and not manual input from pilots based on the display.

d. Misconstruction of equipment regulation

CTIA also mischaracterizes equipment authorization requirements applicable to aviation equipment. CTIA claims that one of the altimeters included in the MSG Report is an outdated outlier because of when the radio altimeter model received its equipment authorization from the Commission. All the radio altimeters tested during the RTCA MSG process are FAA-approved (under the TSO process), FCC-certificated (under 47 CFR Parts 2 and 87), and currently produced, installed, and in use today. The particular radio altimeter unit used in the testing process that CTIA attempts to disparage as being 40 years old, is a unit manufactured in 2020 of a model that is currently TSO-approved and widely deployed on helicopters and fixed-wing aircraft.[36] CTIA's allegations that the results for UC2 and UC3 should be disqualified due to the performance of what it inappropriately characterized as an "outdated outlier" are baseless and without merit.

4. CTIA Relies on Inappropriate Comparisons to Unrelated Studies and Misuses Anecdotes to Claim Public and Aviation Safety Will Not Be at Risk, and Committed Other Errors Not Discussed Above

a. Inappropriate comparison with previous unrelated studies

The CTIA March 4 Ex Parte incorrectly points to preliminary studies investigating compatibility between Wireless Avionics Intra-Communications ("WAIC") systems and radio altimeters with interference as a model for how interference from 3.7 GHz operations to radio altimeters should be assessed.[37] The WAIC studies referenced by CTIA predate the MSG Report and represented *preliminary* assessments shared with international aviation spectrum experts for feedback and development. Underscoring why reference to this earlier WAIC assessments does not support CTIA's position, the approach taken in the MSG Report has further informed the ongoing development of WAIC MOPS and ICAO Standards and Recommended Practices ("SARPs"). In other words, the MSG Report will help further protect radio altimeter systems from possible harmful interference from WAIC systems.

Setting aside the preliminary nature of the radio altimeter-WAIC compatibility assessments, CTIA's comparisons are misplaced. For example, CTIA claims that the MSG Report manipulated cable loss values to make them worse for 3.7 GHz transmissions than for WAIC.[38] The claim ignores the context in the uncited reference that explicitly stated that a range of cable losses were studied, and the value representing the overall worst case for radio altimeter susceptibility to WAIC interference was selected (yielding even greater susceptibility to WAIC interference than that with the same cable loss

[36] By FAA regulation, equipment marked with a TSO cannot be delivered from a TSO holder's facility unless it has been shown to meet the marked TSO. 14 CFR § 21.616(c) states that each holder of a TSO authorization must "Ensure that each manufactured article conforms to its approved design, is in a condition for safe operation, and meets the applicable TSO".

[37] CTIA March 4 Ex Parte at 2, n. 5 specifically references "Update on AVSI WAIC-Radio Altimeter Coexistence Testing, Fourth Working Group Meeting of the Frequency Spectrum Management Panel (FSMP – WG/4), ICAO APAC, Bangkok, Thailand, 29 March – 7 April 2017."

[38] *See* CTIA March 4 Ex Parte, Att. at 6.

assumption that was applied for the 5G testing).[39] Work continues on developing standards for WAIC systems at RTCA, ICAO, and EUROCAE, so any references to past preliminary WAIC compatibility studies misrepresents the current state of activity and should be ignored.[40] More fundamentally, while both the preliminary WAIC assessment and the MSG Report involved experimental assessments of harmful interference to radio altimeters, the studies were independent and concern very different technologies. WAIC is intended to be a very low-power communication technology integrated on an aircraft, and part of the aircraft's certification. However, expected 3.7 GHz operations will consist of high-powered base stations and handsets operating without placement controls.

CTIA erroneously claims the MSG Report interference threshold criteria were manipulated to apply stricter criteria to 3.7 GHz systems to artificially inflate the risk for harmful interference.[41] The MSG Report defines these criteria along with a detailed description of how the raw threshold values are incorporated into interference tolerance masks ("ITMs").[42] Experimental and statistical variations in the laboratory measurements are properly incorporated and applied to all 5G interference test data to develop the ITMs in the MSG Report, which do not depend on any testing or data reported in previous unrelated WAIC studies.

It bears repeating that the RTCA MSG process initiated to first determine *if* there was a potential for harmful interference.[43] AVSI determined empirical thresholds for simulated RF worst case environments that are possible under ICAO-regulated airport configurations that may be encountered in actual aircraft operations[44] and 3.7 GHz flexible use operating characteristics defined in the Report and Order. 3.7 GHz operations emissions were modeled based on transmission characteristics provided by wireless industry representatives, which were discussed and clarified in writing and in several telephone conversations of the TWG-3.[45] Comparing the computed 5G power levels at the input to the radio altimeter to the empirical thresholds demonstrates conclusively that there is a credible risk for harmful interference for the realistic aviation scenarios that were analyzed. This credible risk conclusion does not depend on any previous studies or data.

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[39] *See Id.* at 28, 29. CTIA references an "AVSI 2019 WAIC Study" without proper citation, as the figures included in the CTIA March 4 Ex Parte were taken from an unpublished, preliminary AVSI report concerning WAIC testing.

[40] Specifically, the preliminary assessments that CTIA relies on have since been surpassed by additional work done as part of the RTCA MSG process, and now factors such as cable loss, reflection coefficients, and variation of avionics performance due to temperatures, have all now been updated into the WAIC standardization process being pursued in ICAO, RTCA and EUROCAE.

[41] *See* CTIA March 4 Ex Parte, Att. at 2.

[42] *See* MSG Report at 40-41.

[43] As the MSG Report made clear, "[t]he primary goal of this report is to provide a quantitative evaluation of radar altimeter performance regarding RF interference from expected 5G emissions in the adjacent band, as well as a detailed assessment of the resulting risk of such interference occurring and impacting aviation safety. As such, it is envisioned that this report will be useful to those in the aviation industry, the mobile wireless industry, and both aviation and spectrum regulators to understand and appropriately account for this risk. It is the responsibility of members of all of these groups to work together to ensure that critical aviation systems will be protected for the purposes of public safety." *Id.* at 8.

[44] *See* ICAO Annex 14, "Aerodromes – Volume I – Aerodromes Design and Operations" – 8th edition (July 2018).

[45] *See* MSG Report, Appendix B at 116-150.

b. Anecdotal comparisons with other services mislead the Commission

CTIA continues to seek to downplay the threat to aviation by inaccurately comparing permitted 3.7 GHz operations to other services operating in other bands.[46] In an earlier filing, for example, CTIA, without any plausible justification, attempted to equate flexible use base stations and user equipment in the 3.7-3.98 GHz band with a naval surveillance radar operating below 3.65 GHz.[47] Comparison of commercial wireless telecommunications networks that will consist of widely-deployed, high-powered base stations and millions of handsets to a shipborne surveillance radar that differs in operating frequency, peak power, duty cycle, waveform, deployment, and is only operated by the U.S. Navy, is not a valid comparison for establishing the absence of interference from 3.7 GHz operations into radio altimeters. Comparisons of anticipated 3.7 GHz operations permitted by the Report and Order with other existing systems near the 4.2 GHz band are similarly invalid. CTIA draws attention to recent preliminary developments in the global deployment of 5G services to imply that this is proof there will be no interference from 3.7 GHz operations in the United States to radio altimeters. As an initial matter, absence of reports of interference does not prove or disprove interference occurs, especially when deployment of 5G is nascent and thus the existing volume of data from operational experience is completely inadequate to establish the absence of interference let alone the absence of a material threat of harmful interference, consistent with aviation safety standards. In fact, CTIA does not cite sources, but rather simply states that they do not know of any reports of interference.[48]

More important, the CTIA March 4 Ex Parte fails to acknowledge that France had already recognized the seriousness of the potential threat and has imposed obligations on mobile operators to protect radio altimeters.[49] Furthermore, after the CTIA March 4 Ex Parte was filed, the Secretary General of ICAO sent a letter to administrations, including the United States, to consider the serious potential for interference to radio altimeters.[50] The Secretary General states, in part, that:

> ICAO has received studies from several States and organizations regarding the interference potential to radio altimeters. *These studies generally conclude that some radio altimeters will be impacted if high power cellular systems are implemented near the frequency band used by radio altimeters.* Several States have already implemented

[46] CTIA March 4 Ex Parte at 4 ("several existing systems and services (including very high powered federal systems below 3.65 GHz and ground-to-air communications in the adjacent 4.4-4.94 GHz band) would exceed the purported interference tolerance threshold").

[47] *See* Letter of Kara Graves, Assistant Vice President, Regulatory Affairs, and Doug Hyslop, Vice President, Technology and Spectrum Planning, CTIA, to Marlene Dortch, FCC, GN Docket No. 18-122, at 16 (filed Oct. 27, 2020).

[48] *See* CTIA March 4 Ex Parte, Att. at 31-33. The Organizations Supporting Aviation Safety note that next generation mobile services in other countries often operate under much different parameters than the 3.7 GHz operations the Report and Order permits, such as lower power in many instances.

[49] *See* L'Agence Nationale des Fréquences (ANFR) technical note on "Protection of Radio Altimeters in the 4200-4400 MHz Band" (published Nov. 30, 2020), *available at* https://www.anfr.fr/fr/gestion-des-frequences-sites/bande-3490-3800-mhz/.

[50] Letter of Hon. Fang Liu, Secretary General, to ICAO Member Administrations, ICAO, Ref. SP 74/1-21/22 (dated 25 March 2021).

temporary technical, regulatory and operational mitigations on new 5G systems in order to protect radio altimeters while more permanent solutions are being devised.[51]

c. The CTIA March 4 Ex Parte contains other erroneous statements

Many additional errors pervade the CTIA March 4 Ex Parte, but a few of the most concerning are identified and corrected below.

CTIA acknowledges, for instance, the wireless industry submitted views during the public comment period immediately prior to the publication of the MSG Report, but incorrectly describes an issue concerning the modeling of 5G signals that they raised during the review. The CTIA March 4 Ex Parte represents that CTIA commented that "the peak power level is due to an error in the assumed beamforming, which produced a grating lobe."[52] This is not accurate. Its actual comment addressed allegedly incorrect information initially provided by the wireless industry concerning the incorporation of mechanical down tilt in the AAS scan angle.[53] The RTCA MSG responded to this comment by noting that base station antenna patterns were computed in accordance with ITU-R recommendations using the inputs received from wireless industry. Additional analysis was then added in Appendix D of the MSG Report, which made clear that using modified scan angles did not change the fundamental conclusions of the Report.[54] Indeed, as demonstrated in this case, the RTCA MSG consistently and actively sought input from the wireless industry subject matter experts in order to develop the most accurate models possible.

In addition, CTIA erroneously concludes that the 3.7 GHz power level would be 14 dB lower than that reported in Section 10 of the MSG Report. The CTIA March 4 Ex Parte acknowledges the recomputed power levels reported in Appendix D still show harmful interference, but seeks to dismiss this by incorrectly considering the impacts of aircraft pitch and roll.[55] CTIA's analysis does not account for the fact that the radio altimeter antenna pattern in the 3.7-3.98 GHz band is sufficiently wide (±70 degrees) that the aircraft pitch/roll has a negligible effect on the results in most cases. The example mentioned by CTIA in which the aircraft pitch or roll angle has some contribution is in the context of a potential roll maneuver up to 20 degrees for a UC1 aircraft at an altitude of just over 200 feet. CTIA inappropriately claims this is "not a safe maneuver,"[56] despite the actual real-world example provided in the MSG Report demonstrating that this exact maneuver is a component of a common approach path into Reagan National Airport.[57] In addition to other airports which may present analogous

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[51] *Id.* at 1-2 (emphasis added). The Secretary General concluded by encouraging member countries "to consider as a priority, public and aviation safety when deciding how to enable cellular broadband/5G services in radio frequency bands near the bands used by radio altimeters." *Id.* at 2.

[52] CTIA March 4 Ex Parte, Att. at 16.

[53] *See* MSG Report at 167.

[54] *Id.* at 167. *See also id.* at 217, which includes "Overall, the additional analysis results show only minor differences from the original analysis in terms of operational impacts, and the fundamental conclusions drawn from the original analysis are unchanged. Further, the maximum exceedance of the safe interference limit actually increased by about 5 dB for Usage Category 1 and Usage Category 2. For Usage Category 3 the maximum exceedance changed by less than 1 dB, but the interference impacts remain widespread, and as seen in the [helicopter air ambulance] landing scenario analysis there is a potential for even greater interference levels in certain real-world scenarios."

[55] *See* CTIA March 4 Ex Parte, Att. at 17.

[56] *Id*.

[57] *See* MSG Report at 205.

circumstances, such a maneuver might be necessary in emergency situations generally and should not be discounted by the Commission. Further, effects from aircraft pitch/roll are completely negligible when considering the fundamental emissions interference risks from 3.7 GHz for UC2 and UC3 aircraft.

The CTIA March 4 Ex Parte also adds up isolated, alleged improvements to the carrier-to-interference (C/I) ratio,[58] many of which are explained above to be without technical merit, which leads CTIA to dangerously conclude that the less-than-worst-case conditions they advocate would raise the radio altimeter interference thresholds for all models by up to 65 dB over what is presented in the MSG Report. However, CTIA provides no analysis to support their addition. Specifically, it has not been shown that the interference tolerance masks ("ITMs") in the MSG Report are defined by a fixed carrier-to-interference ratio, so it is not known if an increase in the desired signal level (in dB) produces a one-to-one dB increase in the ITM. While AVSI black-box testing was not designed to determine specific interference mechanisms to infer such a one-to-one relationship, the measurements suggest that this will not be the case for the out-of-band interference signals that were studied.

Conclusion

The MSG Report was produced through a collaboration of experts employing best-practice aviation safety analysis and concludes that new 3.7 GHz operations will produce harmful interference to radio altimeters on all types of aircraft in a number of real-world scenarios. The conclusions are backed by empirical evidence and sound analysis. Additionally, the MSG Report encourages additional, serious, and cooperative investigation to answer questions that were outside the scope of the RTCA MSG effort in order to determine the best path forward for implementing new 3.7 GHz operations while preserving aviation safety. Unfortunately, due to a myriad of technical errors and misunderstanding, the CTIA March 4 Ex Parte is fundamentally flawed and does not contribute to this continued investigation.

[58] *See* CTIA March 4 Ex Parte, Att. at 19.

Attachment C

Analysis of FAA Obstruction Rules and
Analysis of Existing Towers Nearby Airport Approaches

The CTIA March 4 Ex Parte claims[1] the MSG Report[2] Worst-Case Landing Scenario ("WCLS") "would require placing the 5G tower in a location that violates FAA rules about obstructions to air navigation" in order for the landing aircraft to experience harmful interference from 3.7 GHz operations.[3] Contrary to CTIA's claim, the following analysis demonstrates (1) that applicable Federal Aviation Administration ("FAA") rules allow an obstacle such as base station tower to be located near a precision approach runway threshold and (2) the thousands of base station towers currently in close proximity to airports suggest, assuming some if not many may be repurposed for 3.7 GHz operations,[4] that there is a widespread and increasing risk of harmful interference to all radio altimeter Usage Categories.

1. Analysis of FAA Obstruction Rules

CTIA does not cite the specific "FAA rules about obstructions to air navigation" and offers no analysis to support its defective claim. The following analysis provides a detailed explanation of FAA obstruction rules and clearly shows an obstacle such as base station tower can indeed be located nearby a precision approach runway threshold without violating "FAA rules about obstructions to air navigation". The surfaces only relate to physical structures and not spectrum which is why a spectrum analysis is required and approved by a spectrum manager so that no signal interference conflicts exist. With that said, the physical height of the base station tower could be significantly lower than a part 77 surface area and still cause significant interference with air navigation sources.

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[1] *See* Letter of Kara Graves, Assistant Vice President, Regulatory Affairs, and Doug Hyslop, Vice President, Technology and Spectrum Planning, CTIA, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122 (filed March 4, 2021) ("CTIA March 4 Ex Parte"), Att. at 35.

[2] *See* "Assessment of C-Band Mobile Telecommunications Interference on Low Range Radar Altimeter Operations," RTCA Paper No. 274-20/PMC-2073 (rel. Oct. 7, 2020), attachment to Letter of Terry McVenes, President & CEO, RTCA, Inc., to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122 (filed Oct. 8, 2020) ("MSG Report").

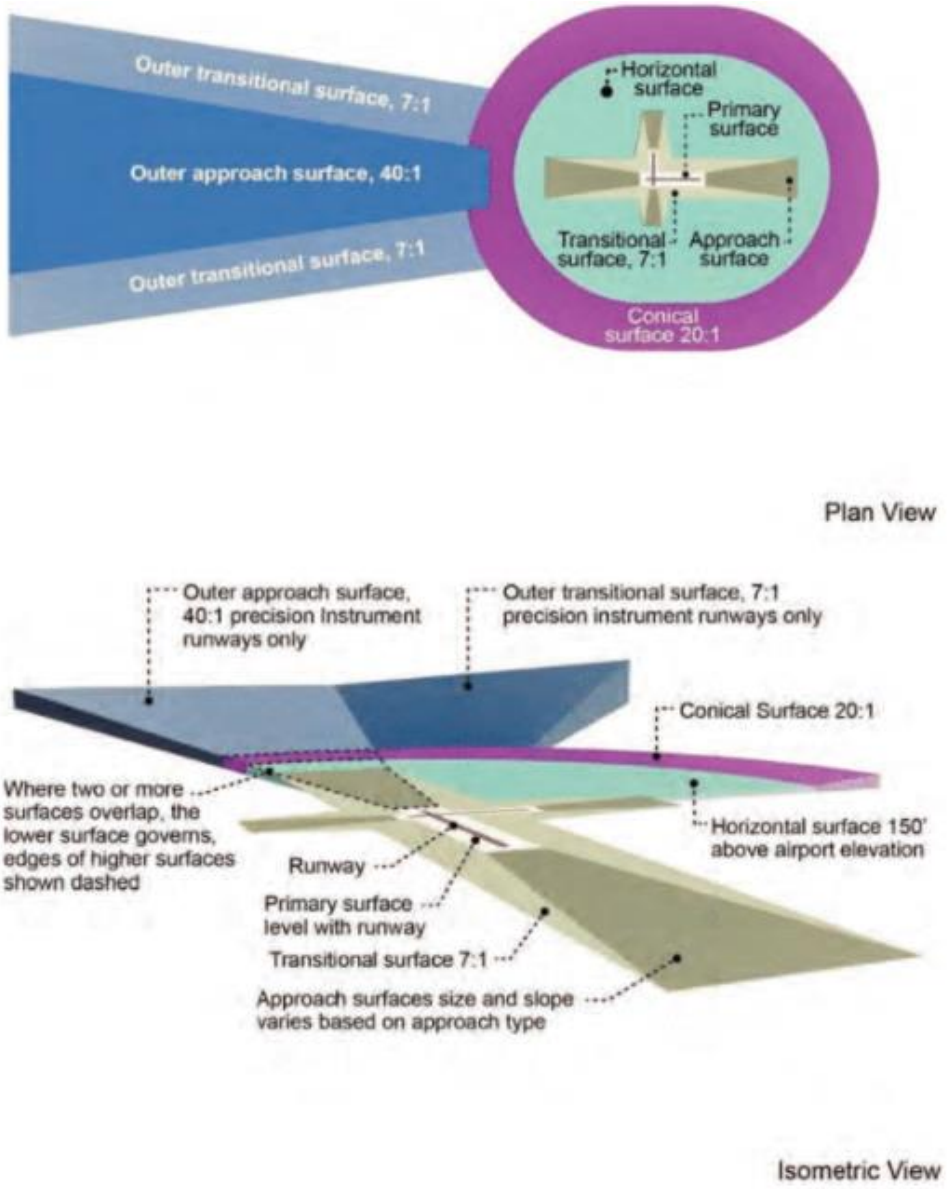
[3] This Attachment hereinafter uses "3.7 GHz operations" to reference 5G and other commercial wireless operations that would be permitted by licensees, i.e., spectrum auctions winners and their successors or spectrum lessees, under the Commission's Rules in the 3.7-3.98 GHz band.

[4] Per a recent article, at least one cellular provider anticipates using existing cell towers to deploy flexible use 3.7 GHz operations. *See* LightReading, Verizon kicks off C-band spending splurge (Apr 12, 2021) stating "Verizon did however offer a few insights into exactly how it plans to work with the tower companies to upgrade its network. The operator said the effort will include the installation of 'new network equipment including basebands and antennas,' and the hardware would be placed on 'existing towers.'" *available at* https://www.lightreading.com/5g/verizon-kicks-off-c-band-spending-splurge/d/d-id/768703.

a. FAA Part 77 Obstruction Standards Analysis

The rules of interest for civil airport takeoff and landing areas are those defined by 14 C.F.R. § 77.19 "Civil airport imaginary surfaces" (referred to hereinafter as "§ 77.19"). The Section 77.19 surfaces define the minimum obstruction heights a physical structure should remain below its respective surface to allow maximum throughput/access to the airport.

The following depicts the various § 77.19 surfaces.[5]



Source: Hanson Professional Services Inc., 2017

Figure 3.1. FAR Part 77 surfaces graphic.

[5] The source for the diagram is Airport Cooperative Research Program, Research Report 195, Best Practices for Airport Obstruction Management Guidebook (2019), Figure 3.1 at 29 *available at* https://www.nap.edu/read/25399.

A discussion of the various types of civil airport imaginary surfaces defined in § 77.19 follows:

(a) Horizontal surface. The horizontal surface is depicted in the figure above as an aqua oval. The horizontal surface, per § 77.19(a), is a "horizontal plane 150 feet above the established airport elevation". Consequently, a base station tower as high as 150 above ground level ("AGL") could be accommodated by this rule if it is located on ground level with or lower than the airport elevation.

(b) Conical surface. The conical surface is depicted in the figure above as a magenta oval. The conical surface defined by § 77.19(b) extends "outward and upward from the periphery of the horizontal surface" at a 20:1 slope ratio.[6] Since the conical surface "extend[s] outward and upward from the … horizontal surface", it could likewise accommodate a base station tower of at least 150 AGL if it is sited on ground level with or lower than the airport elevation.

(c) Primary surface. The primary surface is depicted in the figure above as a white rectangle. For a precision approach to a hard surface runway, such as the instrument landing system ("ILS") approach used in the WCLS, § 77.19(c) states the primary surface "is longitudinally centered on a runway" and "extends 200 feet beyond each end of that runway", that the "elevation of any point on the primary surface is the same as the elevation of the nearest point on the runway centerline", and that the width is "1,000 feet". In other words, the surface at any point perpendicular to the runway centerline out to a width of 500 feet either side of the runway is level with the elevation at the runway centerline. Consequently, a base station tower could not be located anywhere within 500 feet of the runway centerline.

(d) Approach surface. The figure above depicts the approach surfaces as trapezoids with the inner approach surface shown in dark gray and the outer precision approach surface shown in dark blue in the plan view and light blue in the isometric view. For the ILS approach used in the WCLS, per § 77.19(d), the approach surface begins 200 feet from the runway threshold at the same 500 feet width from the runway centerline as the primary surface and then expands to a width of 16000 feet at 50200 feet from the runway threshold. This expansion rises from ground level at a 50:1 slope ratio for 10000 feet and then at a 40:1 slope ration for another 40000 feet. Consequently, it could be possible to site a 75 feet AGL base station tower directly on the runway centerline at 3,950 feet from the runway threshold and a 100 feet AGL base station tower at 5,200 feet from the runway threshold if the elevation at the runway centerline is level or lower than the runway threshold elevation. In fact, these siting examples are *exactly* the type that were shown to exist in the MSG Report WCLS example that demonstrated the risk of harmful interference from 3.7 GHz operations fundamental emissions.[7]

(e) Transitional surface. The figure above uses light grey for the transitional surfaces at or higher than the adjacent primary and inner approach surfaces, and at or lower than the 150 feet AGL horizontal surface. The outer transitional surface adjacent to the outer approach surface is shown in the figure above in light blue in the plan view and dark blue in the isometric view. Per § 77.19(e), the transitional surfaces "extend outward and upward at right angles to the runway centerline and the runway centerline extended at a [7:1 slope ratio] from the sides of the

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[6] FAA procedure design criteria express slope ratios in terms of run over rise. *See* FAA Order 8260.3E, United States Standard for Terminal Instrument Procedures (TERPS) (Sep 17, 2020) at 2-2 ("O8260.3E").

[7] *See* MSG Report, Figure 8-1 at 44.

primary surface and from the sides of the approach surfaces." At the point closest to the runway threshold, the transitional surface begins only 500 feet from the runway centerline. Given this definition, at only 200 feet before the runway threshold, without penetrating the transitional surface, it would be possible to site:

- A 75 feet AGL base station tower that is only 1025 feet from the runway centerline.
- A 150 feet AGL base station tower that is only 1550 feet from the runway centerline. As noted previously, a 150 feet AGL base station tower also will not penetrate the more general horizontal surface that extends to a greater distance from the runway centerline.

In other words, for these two base-station siting examples, a base station tower could be sited nearby a precision approach runway threshold without violating the "FAA rules about obstructions to air navigation".

In summary, the above analysis shows that the only § 77.19 civil airport takeoff and landing area where a base station tower could not be located is the primary surface that is 500 feet to either side of the runway centerline and extends 200 feet beyond each runway end and that a base station tower could be sited within all other § 77.19 surfaces without violating the "FAA rules about obstructions to air navigation."

b. <u>FAA Part 97 Terminal Instrument Procedures Analysis</u>

The rules of interest for standard instrument approach procedures are those defined by 14 C.F.R. Part 97 Subpart C "TERPS Procedures." 14 C.F.R. § 97.20 (referred to hereinafter as "§ 97.20") "prescribes standard instrument approach procedure . . . based on the criteria contained in FAA Order 8260.3, U.S. Standard for Terminal Instrument Procedures ("TERPs"), and other related Orders in the 8260 series that also address instrument procedure design criteria."[8]

CTIA offers FAA Order 8260.3E as the basis for some of its assertions.[9] Among other criteria, O8260.3E includes final segment and missed approach design criteria for conventional precision approaches including those using instrument landing system ("ILS") ground-based navigation aids.[10] But, as noted in § 97.20, O8260.3E does not provide a complete basis for reliance.

In addition to ILS, there are other approach types within the U.S. National Airspace System that have separate documents defining their design criteria. For example, FAA Order 8260.58B "provides guidance for the design and evaluation of Performance Based Navigation … Instrument Flight Procedures …"[11] Among other criteria, O8260.58B includes final segment design criteria for localizer performance with vertical guidance ("LPV") approaches.[12] LPV approaches are flown using navigation guidance from equipment capable of positioning using signals received from global positioning system

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[8] 14 C.F.R. § 97.20(a).

[9] *See, e.g.,* CTIA March 4 Ex Parte, Att. at 11 and 35. *See also* O8260.3E, Chapter 10.

[10] *Id.* at 10-1-10-16

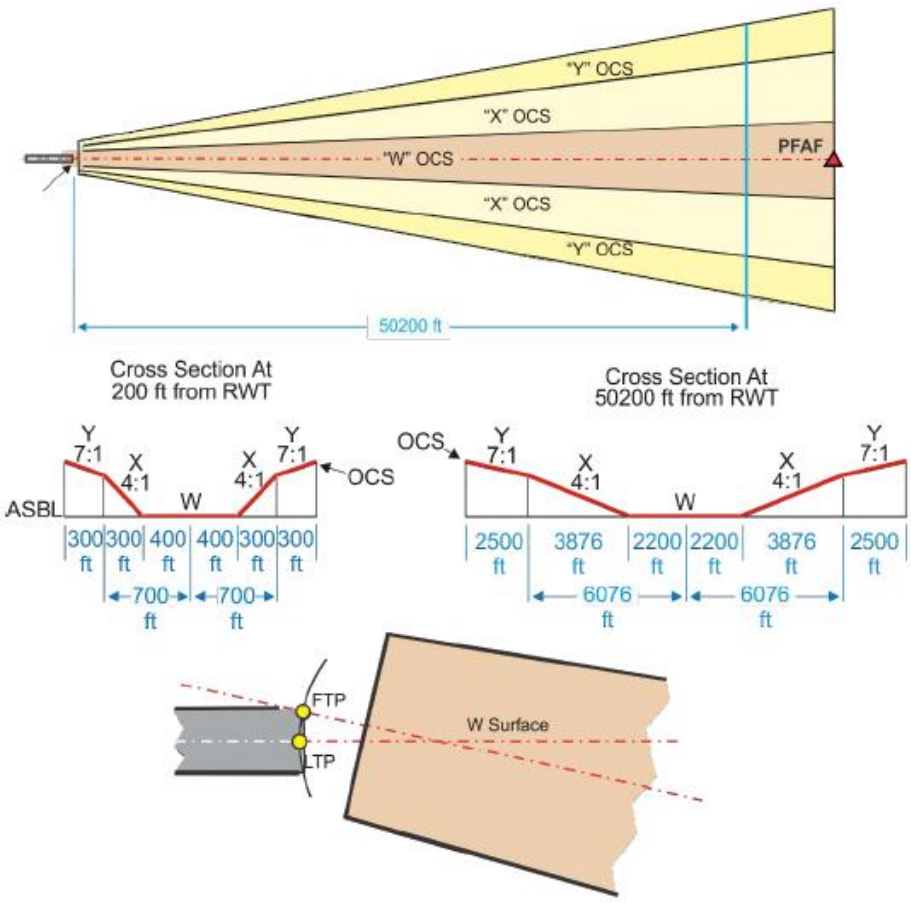
[11] FAA, Order 8260.58B, United States Standard for Performance Based Navigation (PBN) Instrument Procedure Design (Aug 24, 2020) at 1-1 ("O8260.58B").

[12] *See id.*, Section 3-4 at 3-22-3-32.

("GPS") and satellite-based augmentation system ("SBAS") satellites. LPV approaches can be designed to the same minimum 200 feet AGL height above touchdown ("HAT") as ILS Category I approaches.[13]

Figure 10-2-1 from O8260.3E, reproduced below, depicts the obstacle evaluation area ("OEA")/obstacle clearance surface ("OCS") for an ILS Category I final segment.[14]

Figure 10-2-1. Final Segment OEA/OCS



O8260.58B specifies an identical LPV final segment OEA/OCS to that used to design ILS final segments.[15] Figure 3-4-3 from O8260.58B, reproduced below, provides a 3-dimensional view of the LPV final segment OCS that likewise applies to ILS final segments.[16]

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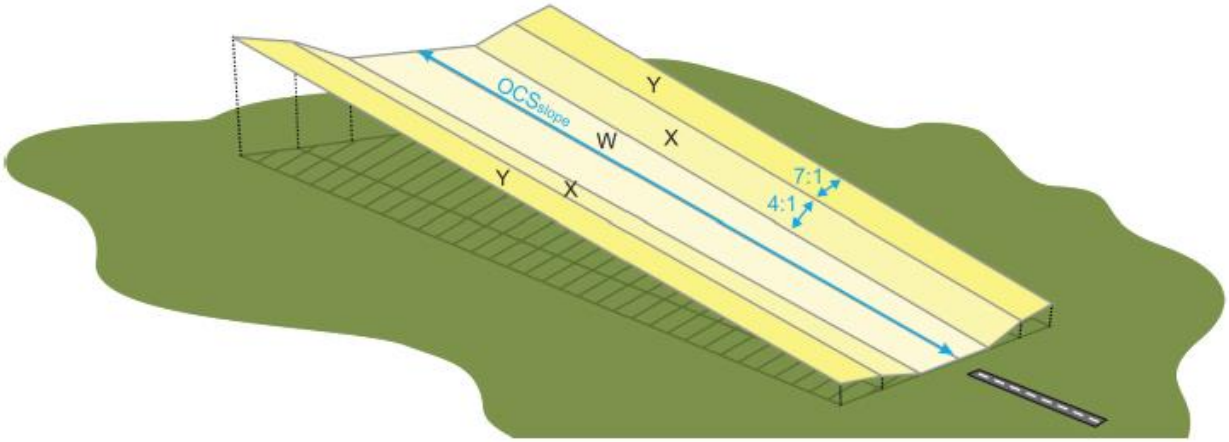
[13] *See id.*, Section 3-4-5 at 3-28 ("the minimum HAT is 200 feet.") *See also*, O8260.3E, Table 3-2-2 at 3-8 for ILS approaches.

[14] *Id.*, Figure 10-2-1 at 10-6.

[15] *See* O8260.58B, Figure 3-4-2 at 3-23.

[16] *See id.*, Figure 3-4-3 at 3-23.

Figure 3–4–3. LPV/GLS Final OCSs



At its narrowest point, 200 feet before the runway threshold ("RWT"), the final segment OEA has a cross section distance of 1000 feet to each side of the final segment course centerline. At its narrowest point, the "W" OCS is level with the ground for 400 feet either side of the final segment course centerline. Then the "X" OCS begins at ground level rising for 300 feet at a 4:1 slope ratio to a height of 75 feet AGL. Finally, the "Y" OCS begins at 75 feet rising for 300 feet at a 7:1 slope ratio to a height of approximately 118 feet.

Given these surfaces, at only 200 feet before the runway threshold, without penetrating the OCS, it would be possible to site:

- A 75 feet AGL 5G base station tower that is only 700 feet from the runway centerline (the point where the "X" and "Y" OCS meet).
- A 117 feet AGL 5G base station tower that is only 1000 feet from the runway centerline (the outer edge of the "Y" OCS).

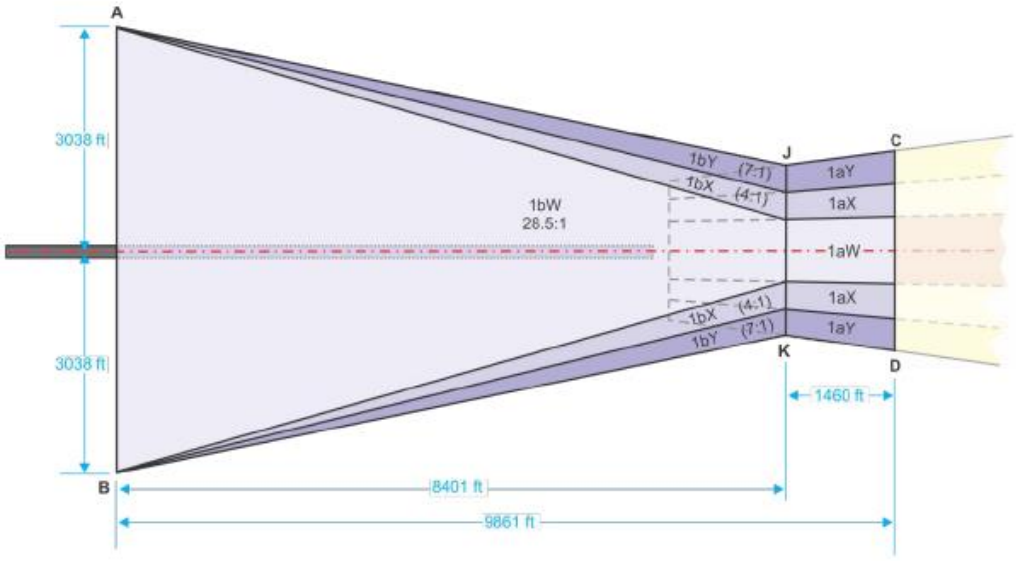
In other words, for these two base-station siting examples, the towers could be even closer than allowed by § 77.19 without violating "FAA rules about obstructions to air navigation".[17]

O8260.3E and O8260.58B also use identical missed approach section 1 OEAs as depicted in Figure 10-3-1 from O8260.3E, reproduced below.[18]

[17] O8260.3E allows a path for approving an instrument approach procedure even if an obstacle penetrates a 14 C.F.R. Part 77 imaginary surface. O8260.3E, Section 1-2-3 "Approval" at 1-6 ("Obstacles that penetrate 14 CFR Part 77 imaginary surfaces are obstructions and; therefore, should be marked and lighted per AC 70/7460-1, Obstruction Marking and Lighting. Those penetrating the 14 CFR Part 77 approach and transitional surfaces should be removed or made conspicuous under AC 70/7460-1 (or military equivalent). *Do not deny instrument approach procedures due to inability to mark and light or remove obstacles that violate 14 CFR Part 77 surfaces* (see exception in paragraph 3-3-2.c).") (emphasis added).

[18] O8260.3E, Figure 10-3-1 at 10-17. *See also* O8260.58B, Figure 3-6-5 at 3-40.

Figure 10-3-1. Missed Approach Area Section 1



The missed approach section 1 OEA is subdivided into sections 1a and 1b where:

- Section 1a overlays a portion of the final segment OEA, and
- Section 1b provides a wider overall OEA that begins at a distance further than 200 feet before the runway threshold and rises at a 28.5:1 slope ratio.

Since the missed approach section 1b rises from a distance farther than 200 feet before the runway threshold, the missed approach section 1b can accommodate obstacles of even greater height than those allowed by the final approach "X" and "Y" OCS at 200 feet from the runway threshold without violating "FAA rules about obstructions to air navigation".

In conclusion, the above analysis shows that the § 97.20 instrument procedure design criteria could allow for a base station tower to be sited close to a runway threshold within the final segment and missed approach section 1 OEAs without violating the "FAA rules about obstructions to air navigation."

2. Analysis of Existing Towers Nearby Airport Approaches

Regardless of whether there are existing base station towers that might be repurposed for 5G or that might be newly constructed that do not violate "FAA rules about obstructions to air navigation," the additional analysis performed for the MSG Report after the public comment period showed that all types of radio altimeters were susceptible to 3.7 GHz operations fundamental emissions at horizontal distances greater than 1000 feet from the aircraft. In other words, a base station tower can be far away from a runway threshold and still cause a harmful interference risk.[19] This reality rebuffs CTIA's assertion that the MSG Report airplane landing scenario "would require placing the 5G tower in a location that violates FAA rules about obstructions to air navigation."

[19] Additionally, such a base station tower need not be located on the runway centerline but could be located well to either side and still cause a risk of harmful interference because the radio altimeter antenna pattern in the 3.7-3.98 GHz band is so wide (±70 degrees). *See* MSG Report, Figure 6-11 at 32.

Specifically, for Usage Category 1 ("UC1") radio altimeters, the worst-case analysis in Appendix D of the MSG Report shows that the risk of harmful interference from fundamental emissions is isolated to altitudes less than 250 feet AGL where the airplane would be close to the runway threshold. However, that risk extends to approximately 2200 feet for an aircraft in level attitude, and even farther with some amount of pitch or roll.[20]

Further, for Usage Category 2 ("UC2") radio altimeters, the worst-case analysis in Appendix D of the MSG Report shows that the risk of harmful interference from fundamental emissions extend to distances greater than 9700 feet (1.6 NM) at heights from zero to 2500 feet AGL, regardless of the aircraft pitch or roll angle.[21]

To demonstrate the pervasive nature of the harmful interference risk, an analysis was conducted of current FCC Antenna Structure Registration ("ASR") database towers (ASR data as of May 2, 2021) against current U.S. airport runways having an ILS or LPV approach. Only constructed towers having an owner or representative internet address that included "ATT", "Sprint", "T-Mobile", "USCellular", or "Verizon" were used for the analysis.[22] The distance from each tower to each airport runway threshold was then computed.

It was found that, currently, there are:

- Over 225 towers within 2200 feet of current airport runway thresholds having an ILS or LPV approach. Many of these towers are nearby large airports having commercial service such as Chicago O'Hare International Airport ("KORD") and Phoenix Sky Harbor International Airport ("KPHX") where airplanes equipped with UC1 radio altimeters regularly operate.
- Nearly 4150 towers within 9700 feet of current airport runway thresholds having an ILS or LPV approach where airplanes equipped with UC2 radio altimeters regularly operate.[23]

Additionally, the harmful interference risk is increasing. The distance calculation was repeated using ASR database towers from June 2020 and comparisons made against the findings from the current ASR database tower calculation. It was determined that there are now:

- Thirty more towers within 2200 feet of current airport runway thresholds having an ILS or LPV approach than in June 2020.
- Over 500 more towers within 9700 feet of current airport runway thresholds having an ILS or LPV approach than in June 2020.

Further still, the risk is even more widespread for helicopter operations, Usage Category 3 ("UC3"), which are far less constrained at low altitude than for fixed-wing aircraft. As with UC2, the worst-case analysis in Appendix D of the MSG Report, analysis for UC3 radio altimeters shows that the

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[20] *See id.*, Figure D-1 at 204 and Figure D-2 at 205.

[21] *See id.*, Figure D-8 at 208.

[22] Capitalization of the provider name was ignored for the purpose of selecting the towers.

[23] Notably, over 94% of the nearly 4150 towers had a height of 150 feet or less, which means they could, at least theoretically, be placed at a location 200 feet before the runway threshold and within 1550 feet or less of the runway centerline and not violate "FAA rules about obstructions to air navigation".

risk of harmful interference from fundamental emissions extend to distances greater than 9700 feet (1.6 NM) at heights from zero to 2500 feet AGL, regardless of the pitch or roll angle.[24]

Summary

Contrary to CTIA's claim, the Analysis of FAA Obstruction Rules shows these rules allow an obstacle such as a base station tower to be located in close proximity to a precision approach runway threshold. More importantly, the Analysis of Existing Towers Nearby Airport Approaches shows there is a widespread and growing risk of harmful interference to all radio altimeter Usage Categories from base station towers that may be repurposed for 3.7 GHz operations far away from a runway threshold.

Thus, the CTIA March 4 Ex Parte claim that the MSG Report worst-case landing scenario "would require placing the 5G tower in a location that violates FAA rules about obstructions to air navigation" is meritless and should be rejected by the Commission. Further, the foregoing analyses demonstrate the considerable effort and rigor needed to fully appreciate and resolve the issues raised by the introduction of 3.7 GHz operations, something the MSG Report supplies in sharp contrast with the CTIA March 4 Ex Parte.

[24] *See* MSG Report, Figure D-12 at 210.